DYNAMIC ROAD SEGMENTATION OF PART OF BOSSO LOCAL GOVERNMENT AREA, NIGER STATE

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ABSTRACT

Dynamic road segmentation (DRS) data model finds maximum application in GIS Transportation (GIS-T) studies and analysis; serving as a data model that splits linear features into new set of segments wherever its attributes change. Attempt has been made by this research to carry out the Dynamic road segmentation of part of Bosso Local Government Area of Minna using an IKONOS image of 1-m Pan-sharpened spatial resolution and other field survey acquired data. Geometric data was acquired using Handheld GPS receivers while the attribute data was acquired via the social survey approach (Administration of questionnaires, direct observations and on-site interviews). A Geo-database was designed and created within the Arc GIS 10.0 version software environment. Analysis and queries were also performed to solve some pertinent issues concerning the route segments and the closest infrastructural facility in case of emergencies. The result highlighted the present road condition of the considered road segments, adjacent land use, traffic congestion rate, notable crime spots and accident hotspots. It also shows that the building up of traffic congestion along the Kpakungu round about axis is due to the road width (8m), high traffic volume and the dilapidating state of the road.

KEYWORDS

GIS in Transportation (GIS-T), Road Network, Dynamic Segmentation (DS), Database, Adjoining Land Use, Crime Rate, Road Traffic Accident.

1.0 INTRODUCTION

Roads are important infrastructures that exhibit distresses due to their constant usage. These distresses, usually in the form of cracks in pavement surface, reduce pavement performance, implying loss of asset value, poor quality of service and constraining the access to remote areas. To avoid such problems, good road maintenance policies are required, relying on the establishment of adequate rehabilitation management procedures.

This technique (DS) computes the map locations of linearly referenced data (for example, attributes stored in a table) at run time so they can be displayed on a map, queried, and analyzed using a GIS. The dynamic segmentation process enables multiple sets of attributes to be associated with any portion of a line feature without segmenting the underlying feature. In the transportation field, examples of such linearly referenced data might include accident sites, road quality, and traffic volume.

Dynamic Segmentation (DS) is a method that facilitates the small areas along a linear feature (road) to be referenced without actually breaking the road into pieces. DS data model is a popular word being used more and more for Geographical Information System for Transportation (GIS-T) analysis, serving as a data model that splits linear features into new set of segments wherever its attributes change. (Scarponcini et al, 1999)

Using GIS as the tool for maintaining and monitoring road network system will open up a wide range of possible application, such as increase in traffic and road condition data acquisition and processing. This will ensure quick and convenient access of relevant and necessary information requisite for planning, design costing and execution of road network project thereby proffering solution to the lingering multivariate problems that are associated with road transportation especially in third world countries like Nigeria.

In many Nigerian cities, the conditions of connecting road networks are mostly dilapidated, not properly maintained or not well designed thereby causing increase in travel time, traffic congestion, increase in road traffic accidents, among other adverse consequences. The cause of this can be traced to successive governments' neglect, overstretched workloads, out-lived design lifespan, structural design defects, sub-standard construction materials and other natural phenomena (Ajani, 2001). GIS application is the best alternate technique used by developed countries in solving these problems by carrying out spatial analysis of the road network usages; thereby informing users on how to locate the road that leads to desired destinations, within the shortest distances.

Wuboys (1995) explained GIS as a computer based information system that enables capture, modeling manipulation, retrieval, analysis and presentation of geographically referenced data. He also gave example of areas of applications in GIS i.e. resources inventing, network analysis, terrain analysis, location analysis, spatial analysis, temporal information analysis. Kufoniyi (1999) stated that the content of spatial database component of GIS depends on the application for which the system is planned.

Using GIS-T as a tool, this paper seeks to map out and analyse the road pavement condition, nature of adjacent land use, notable crime zones and accident prone areas within the study area. Analysis that mines information such as shortest or longest routes (i.e optimal routes) to some public facilities like: hospital, fire service station etc. were also performed on the created Geo-database of the study area. Also to investigate dynamic segmentation as a means of managing road management data and to evaluate the implementation implications for road management systems

2.0 STUDY AREA

The study area is part of Bosso local government in the city of Minna, Niger State, Nigeria. Bosso and environs is the center and major metropolitan of Minna the capital city of Niger State. It lies between Latitudes 9º 31¹ and 9º 40¹ North of Equator, and Longitudes 6º 29¹ and 6º 35¹ East of Greenwich Meridian and has a land mass area of about 884 hectares. Figure 1 shows a diagrammatic presentation of the study area.

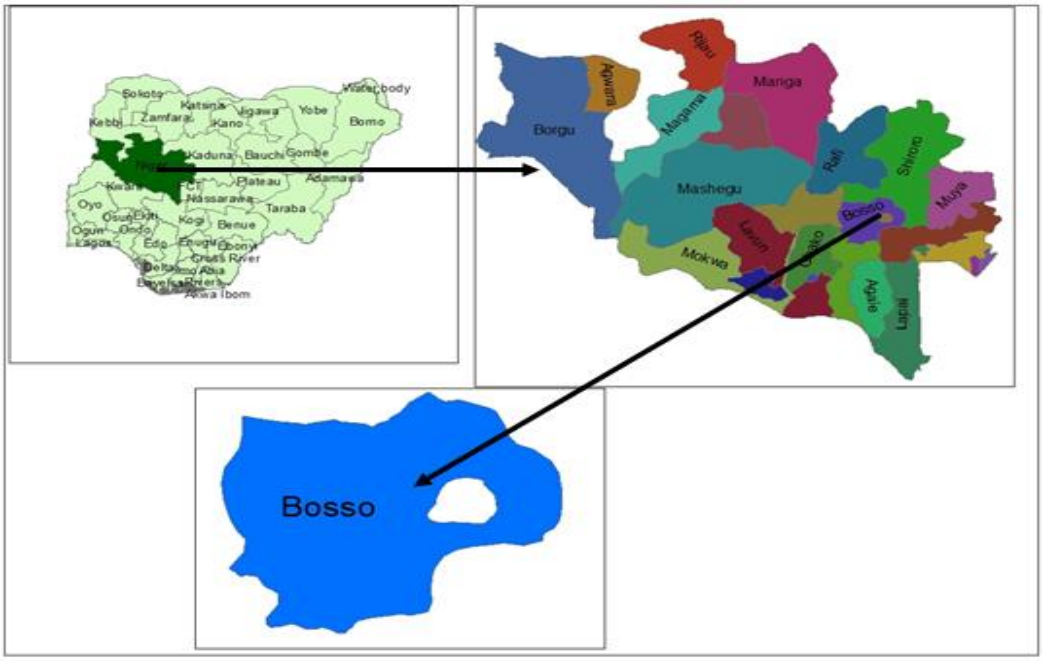

Fig. 1: Plate Showing Maps of the study area

3.0 METHODOLOGY

The general model of the work flow for this research is presented as Figure 2. A schematic diagram of the design and construction phases of a spatial database can be accessed in Kufoniyi (1998).

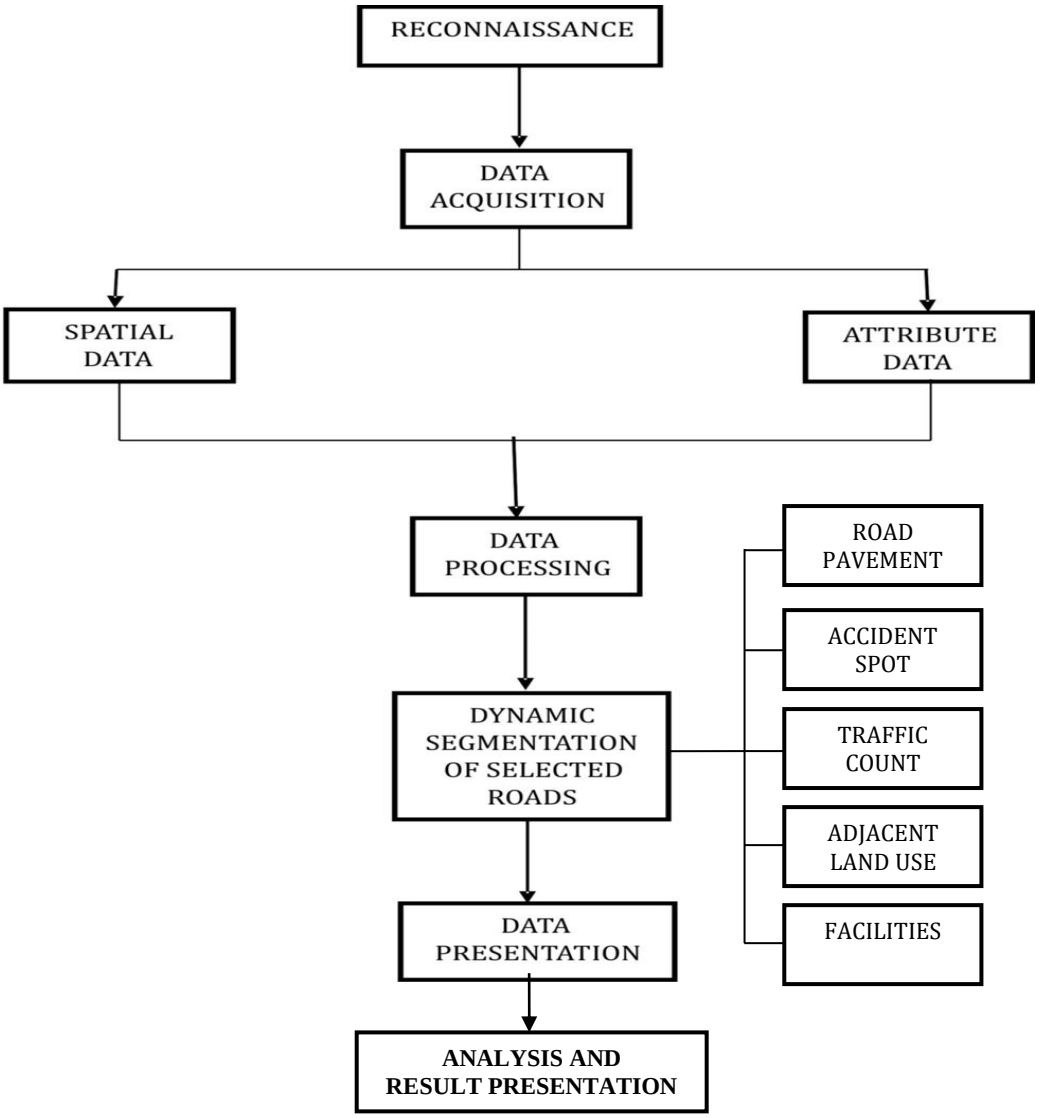

Figure 2: Model of Work Flow of the study

3.1 DATA ACQUISITION

Data acquisition was done using various methods available based on, the extent of the area, the volume of data, the accuracy required and the material involved. It involved the acquisition of both geometric and attribute data. Geometric data were acquired using digital land surveying method while attribute data was acquired through social survey (visualization, direct interviews and questionnaire). Five points were coordinated by differential GPS which were used for georeferencing purpose. The X and Y coordinate of other notable points (such as beginning and end nodes of road segments, crime and accident spots, notable road features such as potholes, etc) were acquired using Garmin 76 Handheld GPS receivers. The satellite image was obtained from the Department of Surveying and Geoinformatics, Federal University of Technology, Minna. The image was acquired in 2005 with a scene dimension of 4km by 6km and spatial resolution (pixel size) of 1m

3.2 ENTITY RELATION-DIAGRAM FOR CONCEPTUAL DESIGN

The relational network of the study area to the origin of the research as described by Entity Relational Diagrams (ER-Diagram) is herein described in Figure 3. Road network is one of the criteria to define a town. Minna being a town in Niger State has certain defining multi-valued attributes of which road system is fundamental.

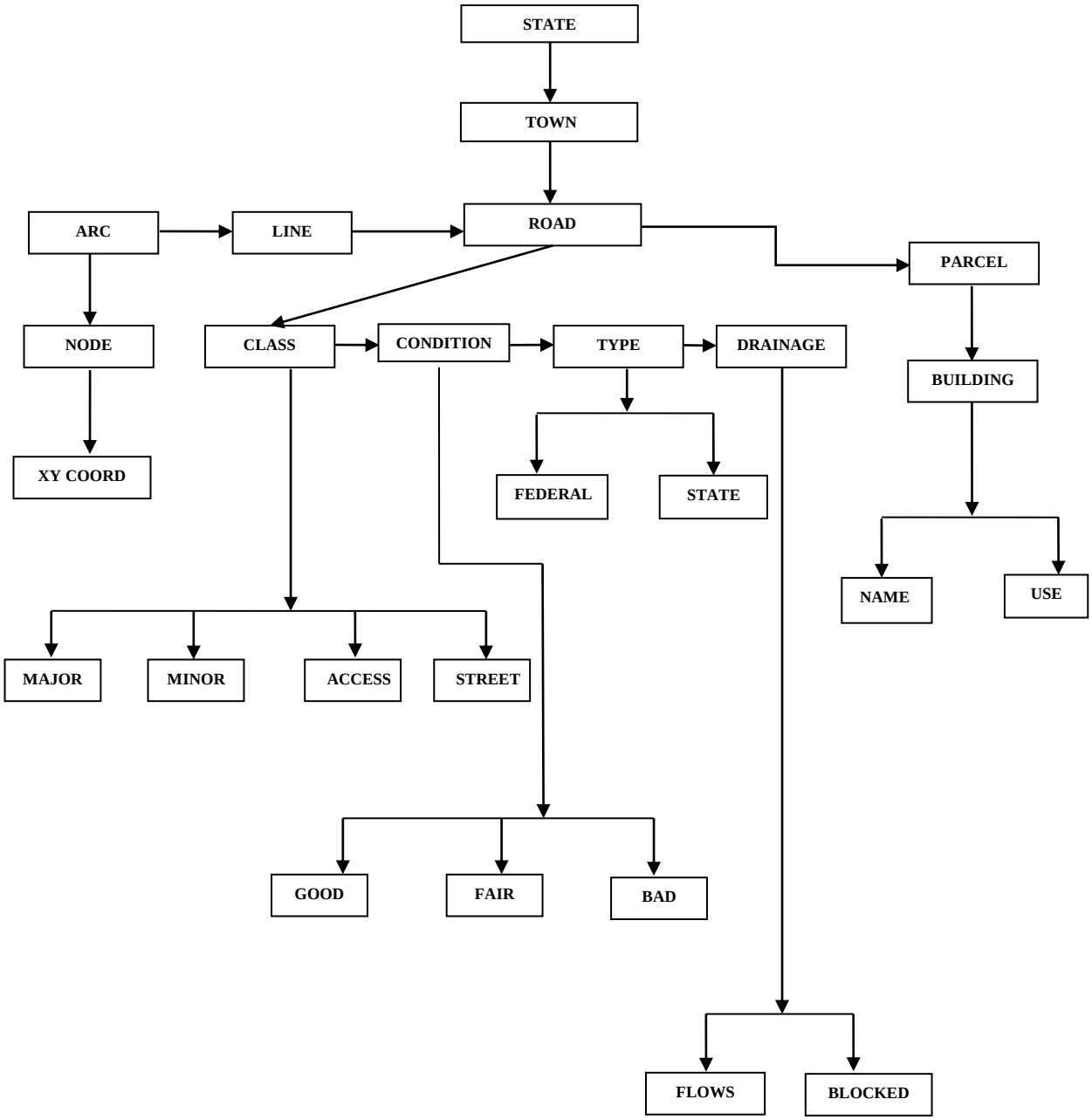

Figure 3: Township Road Networks Entity Relation Diagram (Source: Authors' research)

3.3 DATABASE DESIGN AND CREATION

Database is an organised integrated collection of data stored so as to be capable of use by relevant application with data been accessed by different logical paths (Kufoniyi 1997).The database was created for point, line and polygonal features using a relational data structure wherein features and their attributes were recorded into the appropriate field and tuples.

The design state involves the representation of the data structure in the format of the implementation software, specification of the internal storage structure and file organization for the Dbase, and encoding of the data as transformed in the logical design of the implementation software. It is concerned with defining specific storage structure and access path to the database.

Physical design is all about how data could be physically seen on the computer i.e. how the system understand the data. Data types that are involved are listed as follows:

- Numeric.
- Integers.
- Decimals.
- Alphabet.
- Alpha numeric.

3.4 ATTRIBUTES DATA AS AN ENTITY

The relationship between entities and their attributes are presented in Figure 4. It also highlights their unique identifier (ID), entity type, class, and other attributes that best describes the entities

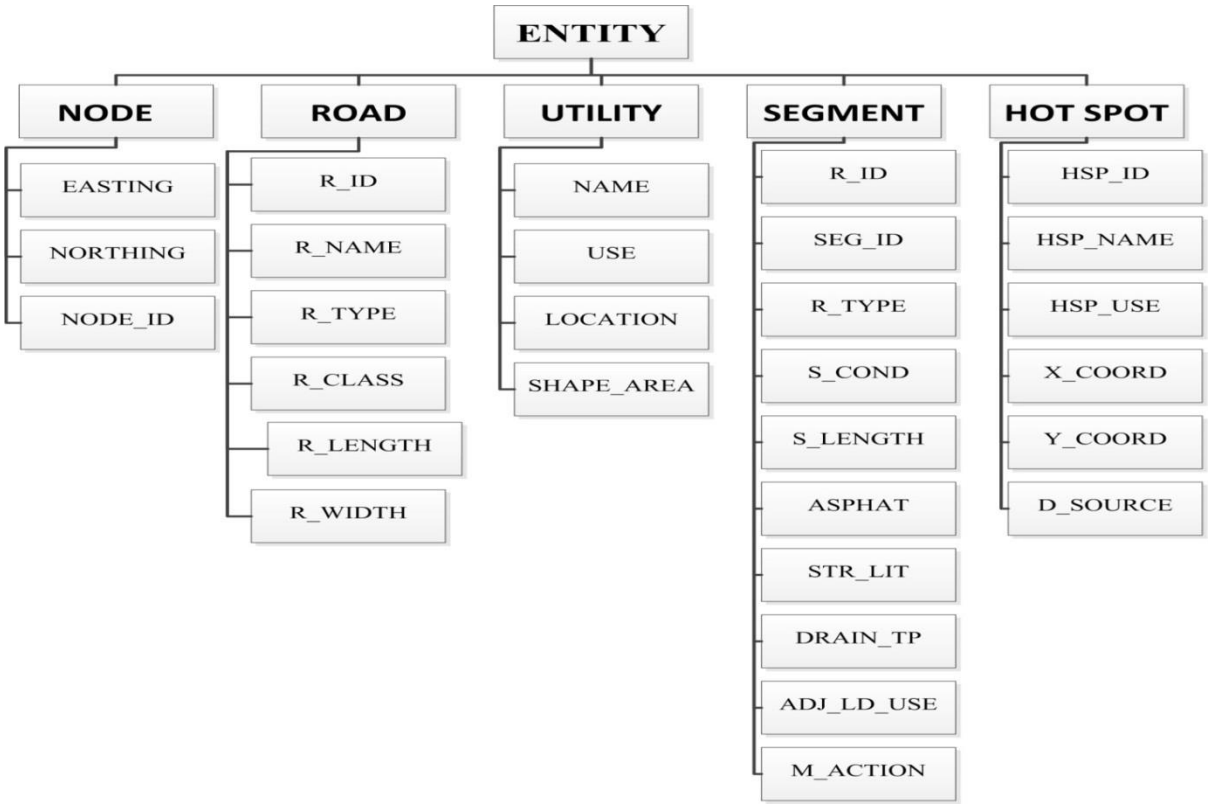

Figure 4. Entities and their Attributes (Source: Authors' research)

3.5 DATA INTEGRITY

Database integrity is ensuring that the data in the database is accurate. Optimal care was ensured while inputting and processing the data. Data integrity was also ensured, by permitting a database administrator to design validating procedures to be carried out when ever an update operation is attempted.

3.6 TESTING OF DATABASE

This involves ensuring the overall workability of the data base in terms preservation of data integrity during storage and/or retrieval process. This was done by designing a sample query and running the query to see if the desired result is achieved.

3.7 QUERIES

Queries were designed for the purpose of retrieving information from the database. It is a way of obtaining specified information from the database using appropriate commands or syntax, spatial query and analysis for this paper was carried out on features with certain characteristics related to the study area. The queries performed were based on the available database to answer certain generic questions asked from the database.

4.0. RESULTS AND DISCUSSION

The result of the single and multiple queries performed on the database are presented as Figures 5 and 6 respectively. The first query seek to highlight the segments of the road that are in good condition while the second query mines out the segments of the major road that needs to be repaired or which is in a fair condition (See sub-sections 4.1 and 4.2) The result of the network analysis is presented in Subsection 4.3 while subsection 4.4 presents the adjoining land use map and the compostie map showing the accident spots, crime hotspots, location of potholes and nodes defining various road segments.

4.1 SINGLE CRITERION QUERY

A single criterion query was carried out where one condition is used for the design query.
QUERY1

Determination of the available segmented roads in good condition within project area. this is shown in figure 5

Type of analysis: Single criterion

Syntax model: [S_Cond]= “G”

Brief explanation: Good Segmented road condition within the project area

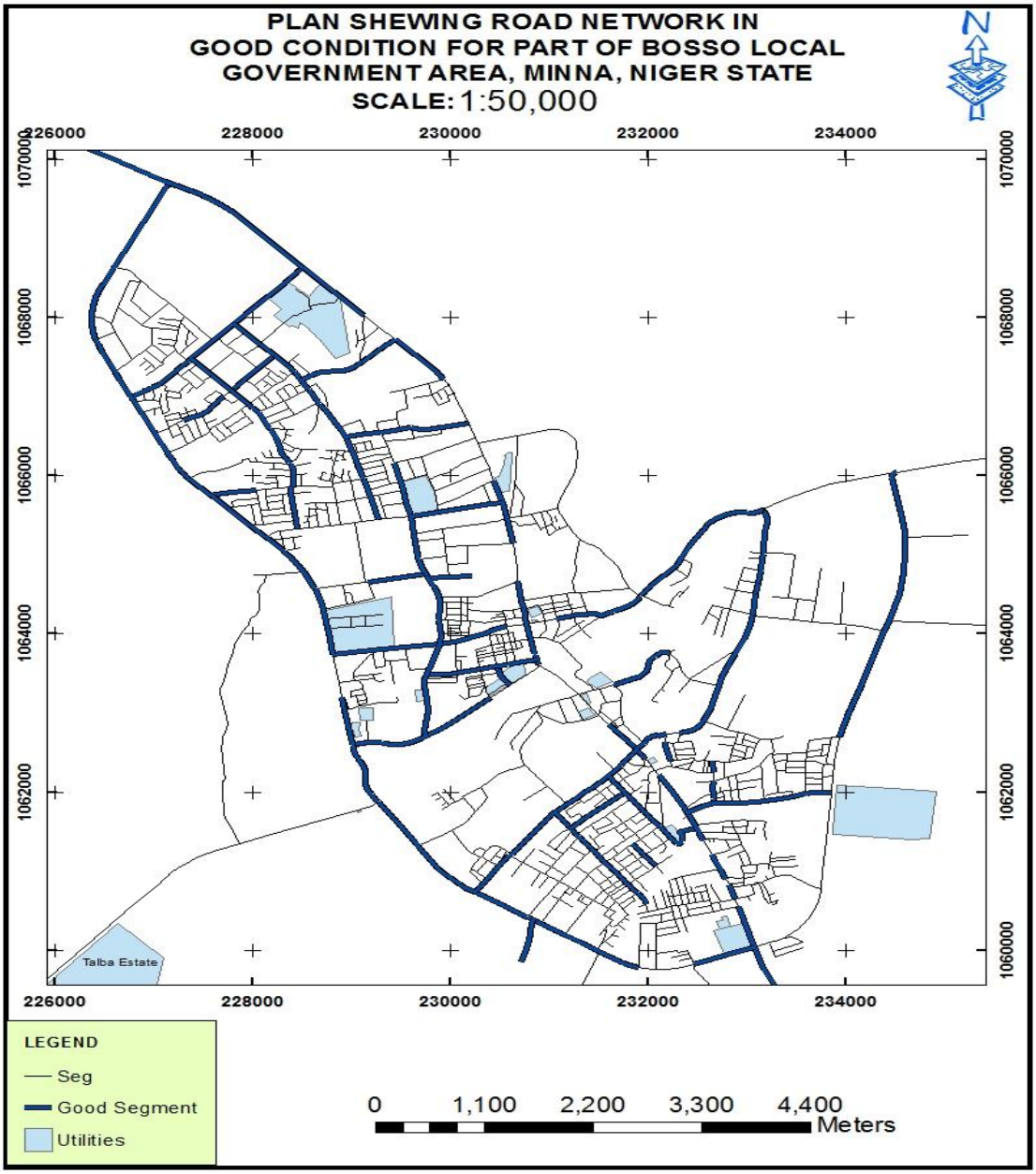

Figure 5. Extracted roads in good condition within project area.

4.2 MULTIPLE CRITERIA QUERY

This is the situation where two or more conditions are imposed in a query operation. Here the two conditions imposed include the road class (major roads) and the road condition (fair condition).

QUERY2

Determination of available major roads that are in a fair condition
Type of analysis: multiple criteria query.
Syntax model: R_Class= “Major” AND S_Cond= “F”
Brief explanation:to determine major roads that are in a fair condition

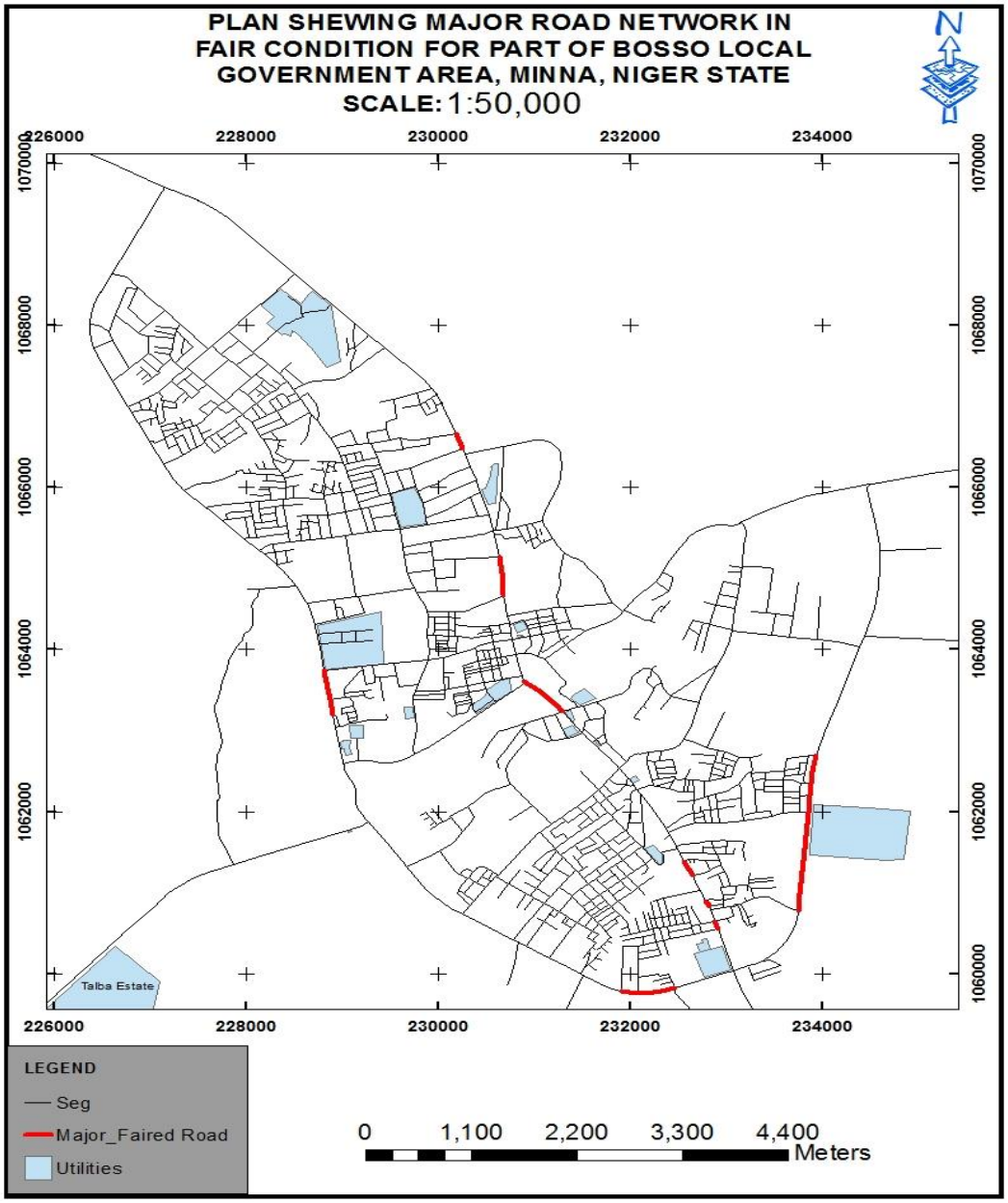

Figure 6. Map of the available major roads that are in fair condition

4.3 NETWORK ANALYSIS

The result of the optimal route analysis for a journey from FUT Mini campus located in Bosso (Starting point) to Kure Market located along the Western Byepass (Destination) is presented in Figure 7 while the route directions with the expected travel time is shown in Figure 8. Based on our study, the journey should take an average travek time of 3 minutes and 4 seconds or a maximum of 4 minutes.

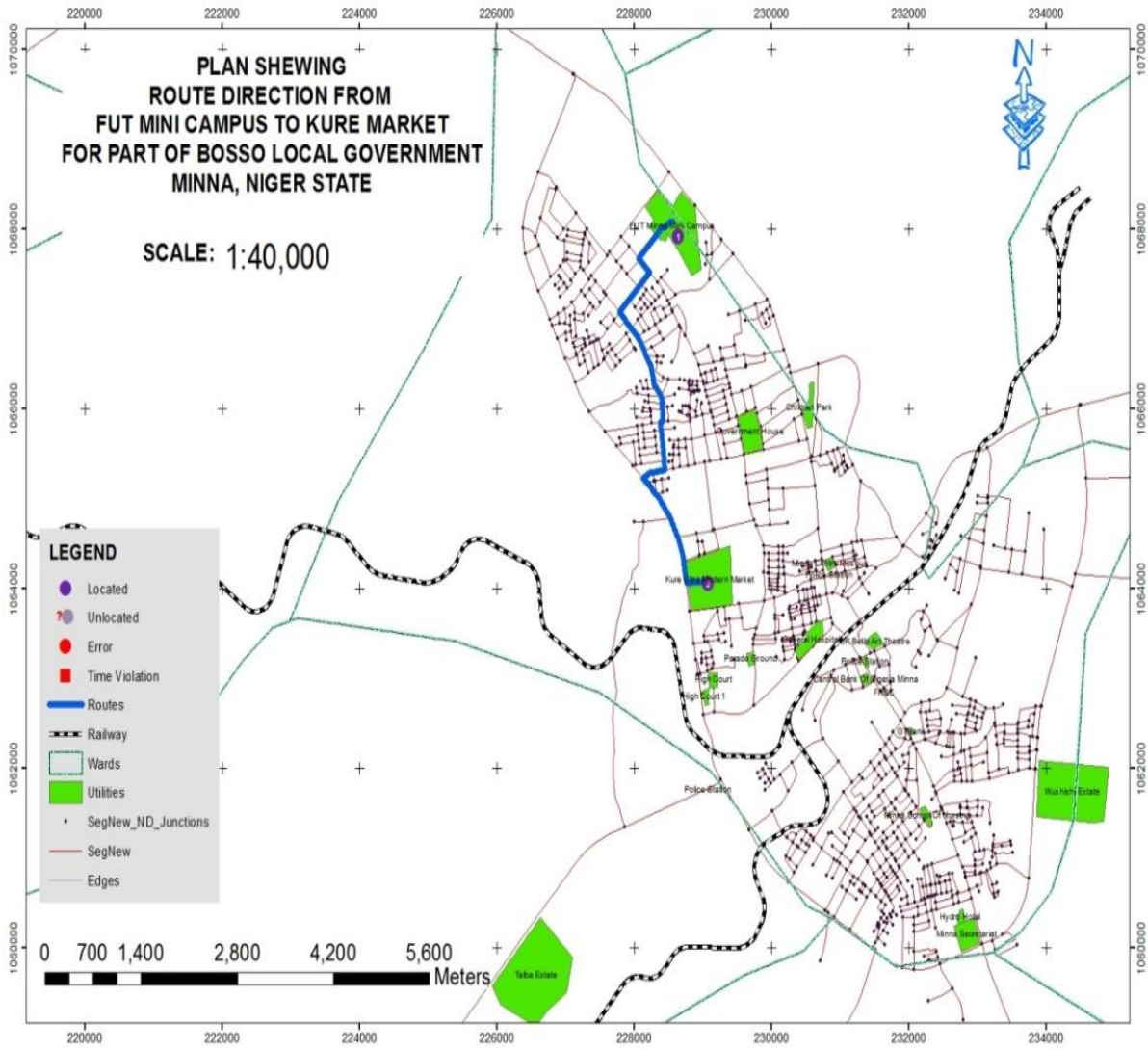

Figure 7. The result for the optimal route between FUT Mini Campus (Starting point) and Kure market (destination).

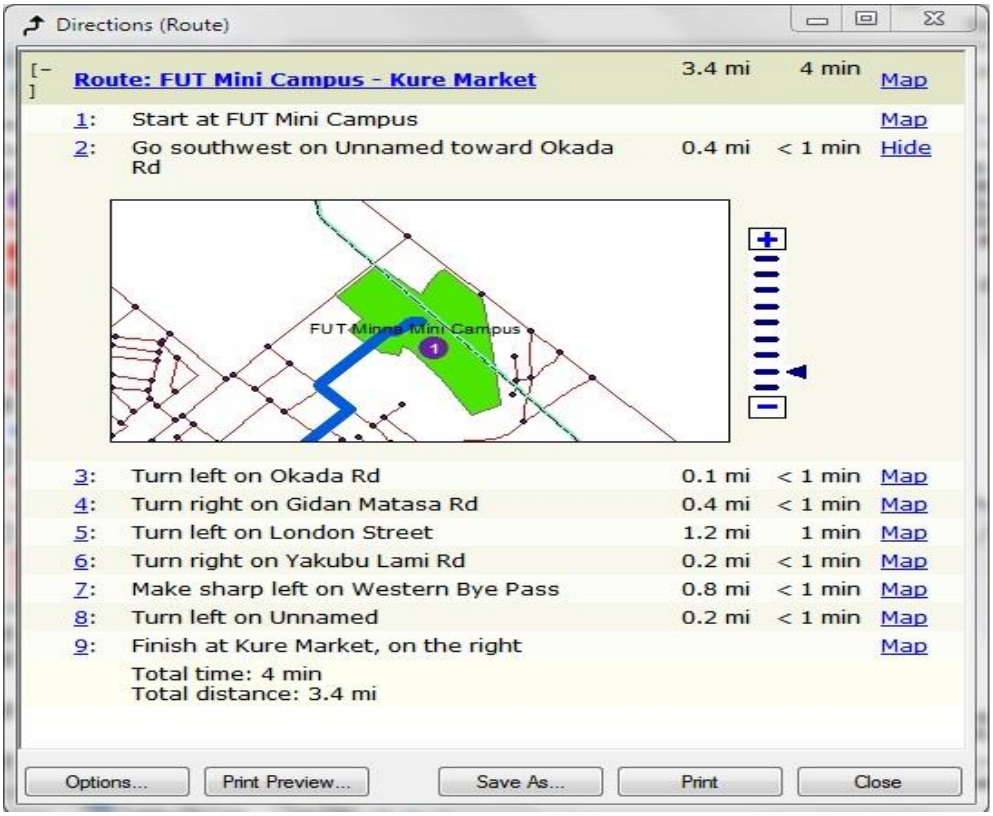

Figure 8. Route direction from starting point and the destination

4.4 PRESENTATION OF THE ROAD SEGMENTATION

Figure 9 shows the dynamic road segmentation separated with nodes, the roads, the road segments, crime scenes, pothole location. The result shows that there is a relationship between the frequency of road accident and the road pavement condition. Objectively, high accident rates were recorded on major roads with a handful of potholes. Such roads also experience traffic congestion even as most road users and commuters complain of difficulty in road navigation. Examples of such road segments include the Kpakungun Round About axis, Shiroro Road, Mobil round about axis, etc. High congestion rate was also recorded along the Kpakungun Round about axis, Mobil Round about, Bosso-Mobil Road, etc.

Figure 10 shows the adjoining land use notable along the road. The notable adjacent land use was grouped into the Residential land use, Commercial land use, Residential/Commercial land Use (Such as houses that was originally designed for residential purposes but now accommodates business outfits) and the Industrial land Use. Mostly, along the major road segments It was discovered that there are business shops signifying commercial land use and after some 50m to 100m inward we have residential land use. It was also recorded that there is only one industrial land use (located at the North western end of the Western byepass) within the study area as at the time of conducting this research.

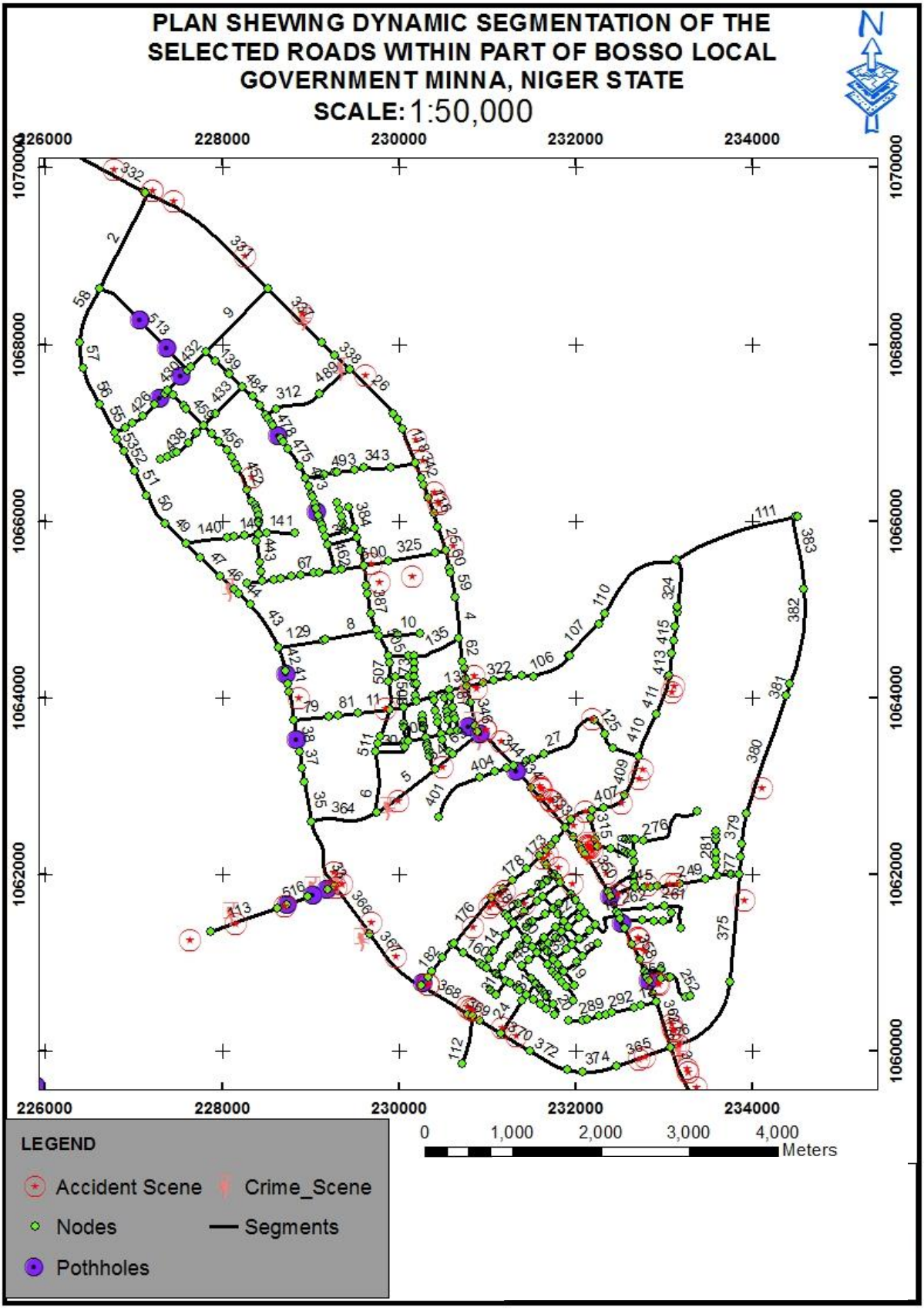

Figure 9. The result for the available potholes and crime scene

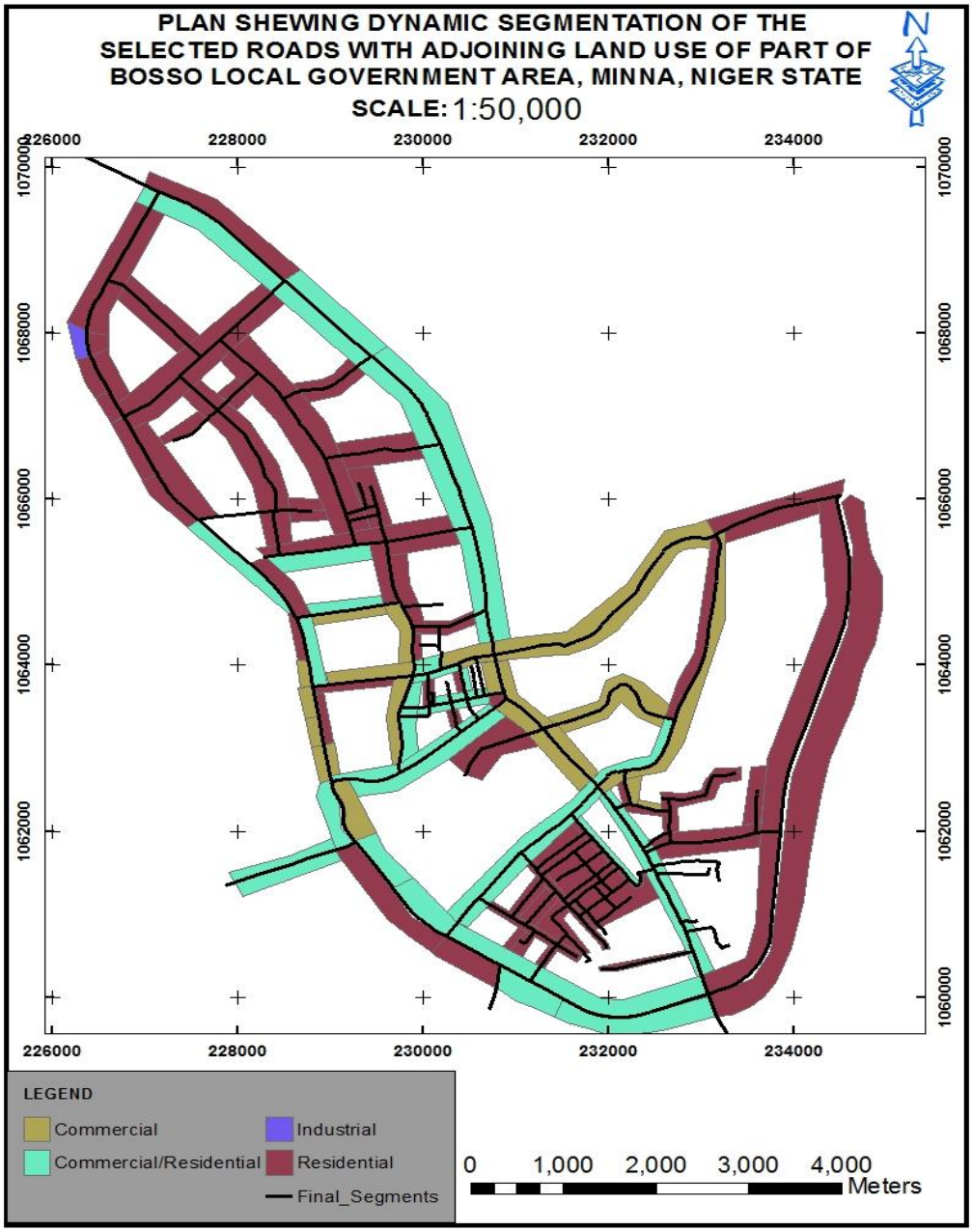

Figure 10. Map for the adjoining land use of part of Bosso LGA, Minna

5.0. CONCLUSION

The following conclusions were made based on the findings of this research:

On the average, a greater portion of Minna roads can be said to be in good condition except for some few spots within the entire road network in Minna metropolis having potholes, narrow widths thereby constituting high traffic volume and workload. Example is the kpakungu axis that connects Minna and Bida. This is frequently experienced around this segment of the metropolis especially between 07h 45mins : 09h 45mins and between 15h 45mins : 16hr 45mins in the evening of the week days. More so the most prominent adjoining land use along the considered road segments is the residential land use and an industry which is operational. This also contributes to increase in travel time because of the impediments posed on the road segments. This research suggests repairs of the few potholes to avoid further spread and expand

the road widths where necessary. There should also be an alternate route to solve the reoccurring problem of traffic congestion in the Kpakungu axis.

REFERENCES

Adeniji, S.A. (1983).Urban Development and Public Transport in Nigeria" Journal of the Nigerian Institute of Town Planners Vol 22, No 1&2 page .56-65

Aderamo, A.J. (1990). Road Development and Urban Expansion: The Case of Nigeria. Ph.D. Thesis submitted to the Department Of Geography University of Ilorin, Ilorin.

Ameyan, O. (1996), Environmental and Energy Issue in Urban Transport System Development" Paper Presented at the FUMTA Seminar on Urban Transport Policy for Nigeria

Aderamo A.J (2003). A Graph Theoretic Analysis of Intra Urban Road Networks In Ilorin, Nigeria Research For Development

Agungu, (2001): GIS Application on Road Network, In Indonesia, Volume1 No2, P.38-46.

Ajibade, S.A. (2000): Computer Programming and Database" A Paper Presented At Federal School Of Surveying, Oyo Seminar Series, Dec, 1999, P7-14.

Anders, K. H and Sester, M., (2000). Parameter-Free Cluster Detection in Spatial Databases and Its Application to typification.

Bello, S.A. (1994). Urban Public Transport in a Growing City: The Case of Ilorin, Nigeria. Ph.D. Thesis Submitted to the Department of Geography, University of Ilorin,

Denners. N (1993). Fundamental of GIS. New-York John Wiley and Sons Inc, Pp 325.

Hansen, H.S. (1993): An Accessibility Analysis of the Impact of Major Changes in the Diannish Infrastructure. Proceedings of Geographical Information System Held in Baller up Denmark 5th Edition (March/April1993) Pp 852 – 859

Encyclopedia Britannica, (1980): Road And Highways, pp 905.

Kufoniyi, O. (1998): "Database Design and Creation" Ezeigbo C.U (Ed), In Principle and Application of GIS Series in Surveying and Geoinformatics, Pan Press, Pp52-57.

Kufoniyi.O (1999) a Paper Delivered At Public Lecture Organized By Enugu State Branch of The Nigerian Institution Of Surveyors (NIS) At Enugu State, Nigeria

Muekereke (1992) GIS Application In Road Network " A Case Study Of Kosobo Phase 2 In Oyo East L.G.A.A Project Report Submitted In Partial Fulfillment Of The Requirement For The Award of Professional Diploma In Surveying And Geoinformatics At The Federal School Of Surveying, Oyo Pp 7

McLeod (2000) "GIS Has Brought Tremendous Benefit to Resort Suffer Its Fair Share of Traffics Related Problem" In Geo Europe Magazine 9th Edition. Pp 39

Oguntade A.O (2005) Creations of Spatial Database For Route Network (A Case Study Of Araromi Estate Phase II In Oyo East LGA). Pp 28.

Wuboys F.M (1995) “GIS A Computing Perspective” London. Taylor Frances Pg 1& 4-21

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